

The National Geographic Magazine

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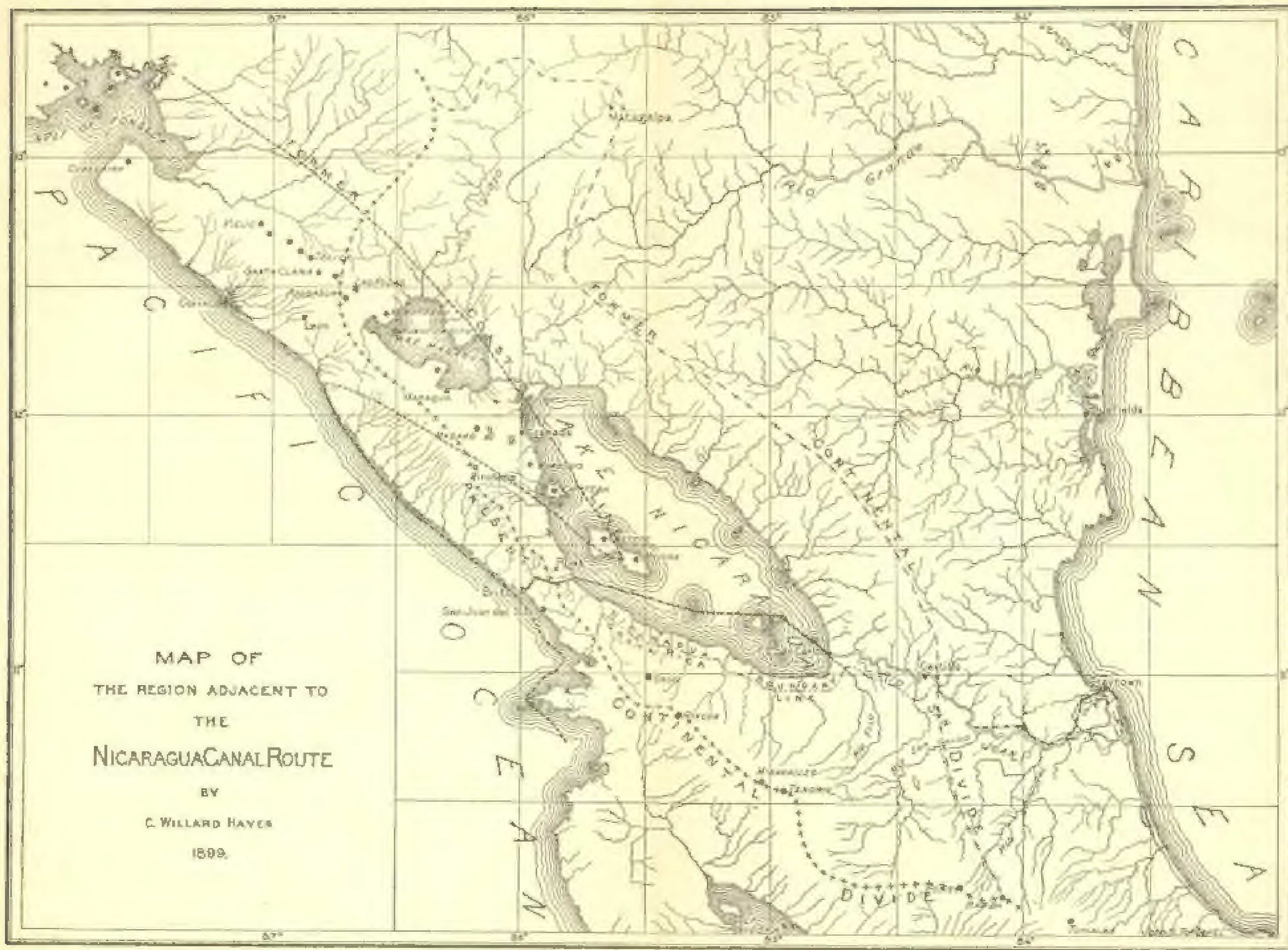
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PHYSIOGRAPHY OF THE NICARAGUA CANAL ROUTE

By C. WILLARD HAYES

United States Geological Survey

The region whose topography and geology have a most intimate bearing upon the problems connected with the proposed Nicaraguan canal embraces northern Costa Rica and southern Nicaragua. It is sharply limited on the south by the high volcanic range of Costa Rica, which rears its massive form diagonally across the isthmus. It is limited to the north somewhat less definitely by the increasing height of a deeply dissected plateau, which merges with the mountains of northern Nicaragua. Between these limits lies a broad irregular depression, which extends very nearly across the isthmus in a diagonal direction parallel with the Costa Rican range. This depression is now occupied chiefly by Atlantic drainage, the continental divide lying within a short distance of the Pacific. It contains the basins of Lakes Nicaragua and Managua and their outlet, the San Juan river. It is important to note that the Nicaraguan depression is not a simple river valley. The portion with which we are chiefly concerned, that lying between the lake and the Caribbean, embraces two distinct drainage basins, whose streams formerly flowed in opposite directions, although by a geologically recent reversal of the drainage they now have a single outlet to the sea.

When examined in detail the surface of the Nicaraguan depression presents considerable relief, and its topographic features naturally group themselves into three classes.

Extending from the base of the Costa Rican volcanoes northward to the San Juan river and beyond are many hills whose

summits reach a tolerably uniform elevation on north and south lines, but increase in height from either side of the isthmus toward its axis. In the vicinity of the San Juan these hills have steep slopes and rounded summits. Some distance back from the San Juan the valleys which separate them are narrower, and there are considerable areas of level or undulating surface at an altitude corresponding with the summits of the hills nearer the center of the depression. It is evident that if the valleys were filled over with the summits of these hills, there would be formed a broad undulating plain, sloping gradually up from either side toward the axis of the isthmus. It is entirely probable that such a plain once existed, and that it has been converted into a series of even-topped hills and ridges by the subsequent cutting of stream channels below its surface. The manner in which this plain was originally formed is manifestly by the long continued action of streams when the land stood considerably lower than now—that is, by the process of stream degradation or basel leveling. It was therefore a gradational, not a constructional, plain. If it were reconstructed by the filling of the stream valleys, its present altitude would vary between 100 and 200 feet.

As indicated above, numerous valleys now intersect the surface of this old plain. Except in the case of the San Juan they vary with the size of the stream which they carry. The reasons for this exception will be pointed out later. The valleys are broad in proportion to the extent to which the old plain has been destroyed, and they grow narrower with increasing distance from the axis of the depression. The smaller streams generally head in narrow gorges. In some cases they have not completely dissected the old plain, but flow upon its surface in shallow valleys which, lower down, give way to narrow gorges, and these in turn to the rather wide alluvial valleys near the trunk stream. The greater part of the erosion which has dissected the surface of the old plain was accomplished when the land stood somewhat higher than at present. The valleys were then much deeper and none had extensive floodplains, except perhaps the largest streams near the sea. The recent change in the altitude of the land has brought the valleys below sea-level, changing the rivers from corrodng to aggrading streams. They have since silted up the estuaries which were thus formed, producing the wide alluvial plains through which they now meander.

Corresponding in some degree to the valleys incised within the old plain are eminences rising distinctly above its surface.

These are residual hills which, by reason of the harder rocks of which they are composed or their position on the divide away from the main drainage lines, were never reduced to the level of the plain. Where the plain was best developed, that is, near the sea margin on either side, these residual hills are infrequent and inconspicuous. To the southward of the San Juan, in the region lying between the Sarapiquí and the San Carlos, there is also an extensive area in which the hills are almost wholly remnants of the dissected plain, their summits in general presenting but little variation in altitude. To the northward of the San Juan the residual hills occur with increasing frequency and greater altitude, and finally merge with the mountains of northern Nicaragua. They also increase in number and height from either side of the isthmus toward its center, being most abundant along a line which crosses the San Juan valley in the vicinity of Castillo. If the old plain were reconstructed by the filling of the present valleys, it would not be continuous across the isthmus, but its eastern and western portions would be separated by an irregular line of these residual hills, the low gaps between them being slightly above the level of the plain.

The relations of these three classes of topographic forms will perhaps be made somewhat clearer by a reference to the accompanying idealized sketch and section on page 236. The surface of the peneplain is indicated by the even summits of the hills to the right. Residual hills are represented to the left, rising abruptly and distinctly above the surface of the peneplain. The profile shows a transverse section of the San Juan valley and a longitudinal section of the valley of a tributary stream. The latter is represented as rising to the residual hills to the left and flowing for some distance in the narrow gorge *a b*. From *b* to *c* the stream flows in a broad shallow valley at about the level of the peneplain. From *c* to *d* it is in a narrow gorge recently cut and still being actively deepened within the peneplain. It emerges from this gorge at *d* and thence to the margin of the main river valley at *e* it meanders through an alluvial plain continuous with the San Juan floodplain *e f*. The bottom of the valleys which the tributary and the trunk stream occupied before the recent depression of the region is represented in the profile by the solid line between the alluvium and the underlying rock. When these valleys were formed they were considerably above sea-level and the streams had a much more rapid fall than at present, but they are now somewhat below sea-level.

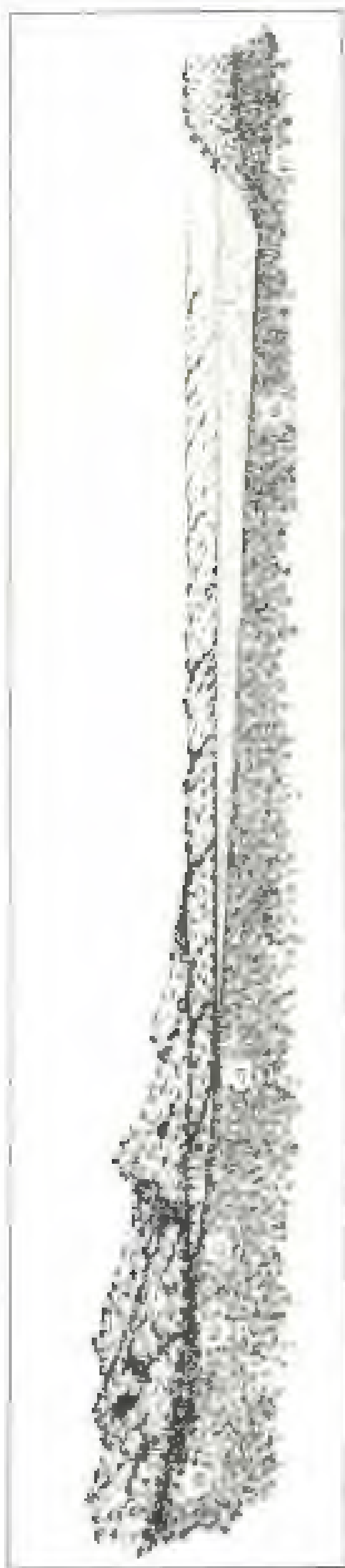


Diagram illustrating the topography of the Nicaraguan depression as a result of the erosion of the Pacific coast.

Summing up the foregoing statements very briefly, it appears that the surface of the Nicaraguan depression consists of a broadly undulating plain formed by the erosion of streams flowing to the Pacific and to the Atlantic from low gaps at the divide. Above this plain are residual hills, most abundant at the axis of the isthmus, where the continental divide was formerly located, but increasing in height along the axis toward the north, where they merge with the mountains of northern Nicaragua, and finally, there are many valleys which have been cut in the surface of the plain by the erosion of streams after the region had been elevated to a higher altitude. The lower portions of these valleys have subsequently been drowned and silted up with the formation of broad alluvial floodplains.

During most of the time in which these topographic features were being developed the Pacific coast had an outline very different from that which it has at present. Lakes Nicaragua and Managua then had no existence, and the region which they now occupy was in part the basins of streams flowing to the Pacific, in part open ocean, and in part a bay which then indented the Pacific coast and whose southern point was near the present island of Madera. The relations of the present and former coast lines are shown on the accompanying map, plate 6.

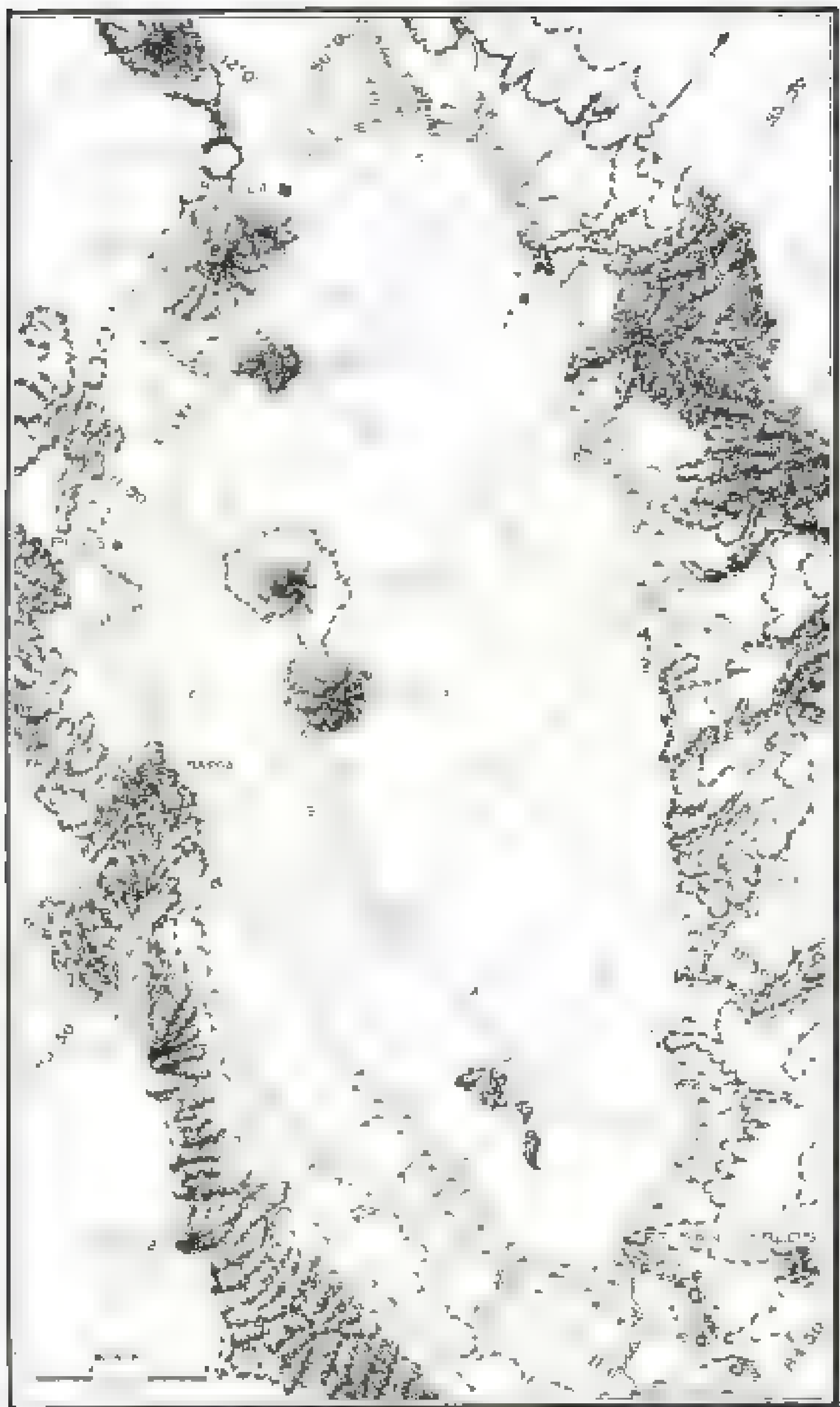
Lake Nicaragua has a regular oval outline, its longer axis extending about northwest-southeast. Its area is very nearly 3,000 square miles, and the mean elevation of its surface is about 104 feet above tide. Its shores present considerable diversity, depending chiefly on the character of the rocks which form them and the direction of the prevailing winds. The trade winds blow with great persistency throughout a large part of the year. They are deflected from their normal course by the high volcanic range of northern Costa Rica, so that instead of being northeast winds they vary from east to east-southeast. As a result of this constant wind direction the southeastern end and northeastern side of the lake rarely experience any surf, and hence those portions of the lake shore have no beach, but are bordered by swamps, with vegetation constantly encroaching upon the lake. Along the southwestern side and western end of the lake, on the other hand, there is a constant heavy surf and as a result a broad sand beach, generally backed by a wave-cut cliff. The accompanying map (page 239), based upon surveys made by the U. S. Nicaragua Canal Commission, shows the configuration of the lake basin. The most interesting feature shown is the old channel, evidently a drowned river channel formed when the southern half of the lake basin was dry land. This channel marks the course of a river formed by the union of the several streams now entering the lower end of the lake with the one which occupies the upper portion of the San Juan valley. It is first detected in the vicinity of the Solentiname islands, and if it was ever excavated between this point and the mouth of the Frio this portion has subsequently been filled by sediment brought into the lower end of the lake. From the Solentiname islands for about 10 miles northwestward there is only a slight indication of the channel. Thence to the base of Madera it is continuous and distinct. The greatest depth in the lake, over 200 feet, is near the western end of this channel.

To the west of the bay, which, as shown on the map, plate 6, formerly indented the Pacific coast, was a long cape or peninsula. This now forms a part of the narrow strip of land occupied by the continental divide between Lake Nicaragua and the Pacific. This part of the Isthmus, although intimately connected with the Nicaraguan depression, is not properly a part of it. Its topography is particularly interesting in connection with the proposed canal, since it contains the lowest gap in the continental divide between the straits of Magellan and the Arctic ocean.

The manner in which this gap was developed is worthy of consideration.

Bordering the lake along its southwestern side is a very perfectly baseleveled plain from five to eight miles in width, which I have called the Rivas plain (see map, page 242). This is probably a portion of the same peneplain which forms the fundamental topographic feature of the Nicaraguan depression, and was at one time doubtless continuous with it. From the lake shore where the waves have cut a narrow terrace backed by a low cliff, the plain ascends toward the southwest at the rate of about 8 feet per mile. Its even surface is interrupted by occasional low residual knobs, which increase toward its inner margin, passing into the continuous ridges and high hills of the main continental divide. The Tola hills which border the Rivas plain on the southwest here extend to the Pacific, although further toward the northwest a narrow coastal plain is developed similar to the Rivas plain on the opposite side of the range.

The Tola hills doubtless correspond to the residual hills which rise above the peneplain of the Nicaraguan depression. They have a serrate outline, the altitude of their summits varying between 800 and 1,800 feet. While this range of hills still formed a long, narrow point of land between the *bay of Nicaragua* and the Pacific, the effect of deformations and wave erosion was such as to make the position of the divide asymmetrical. As shown on the map, it was for a time located very much nearer to the Pacific than to the head of the bay. Hence the streams which headed upon the divide and flowed in opposite directions were of very unequal length. Those flowing east to the bay must have been five or six times longer than those flowing west to the ocean. Such conditions rendered the divide unstable and the familiar process of shifting toward a position of stable equilibrium took place. A stream occupying the position of the lower portion of the Rio Grande, by reason of the advantage which it possessed in having its fall concentrated within a short distance, cut back into the divide and diverted to its own basin successive portions of the opposing stream. At the beginning of the process an eastward-flowing stream occupied the valleys of the present Tola, upper Rio Grande, Guisocoyol, and lower Las Lajas. A small tributary headed against the Pacific stream on the divide in the vicinity of La Flor. This tributary was first reversed and then the upper portion of the original stream, the present Tola, was diverted toward the southwest. The same process was continued



the old divide was pushed back to its present position at least 1000 feet. Streams to the northward also suffered some loss of territory. Thus upper tributaries of the Meana and Coangues were diverted, forming portions of the present Machagón, Managua, and Changuales. The deserted river valleys formerly occupied by the Meana and Coangues flow at Toluá and Casabiel, and from whence have descended Guisocoyol now flows, across the lowest gap in the volcanic divide. Its summit is 154 feet above sea level, and it is here that so great a difference of level that accurate construction work is required to bridge the divide. During the wet season, this gap is occupied by a swampy run, while the water appears to flow out to the Atlantic and Pacific.

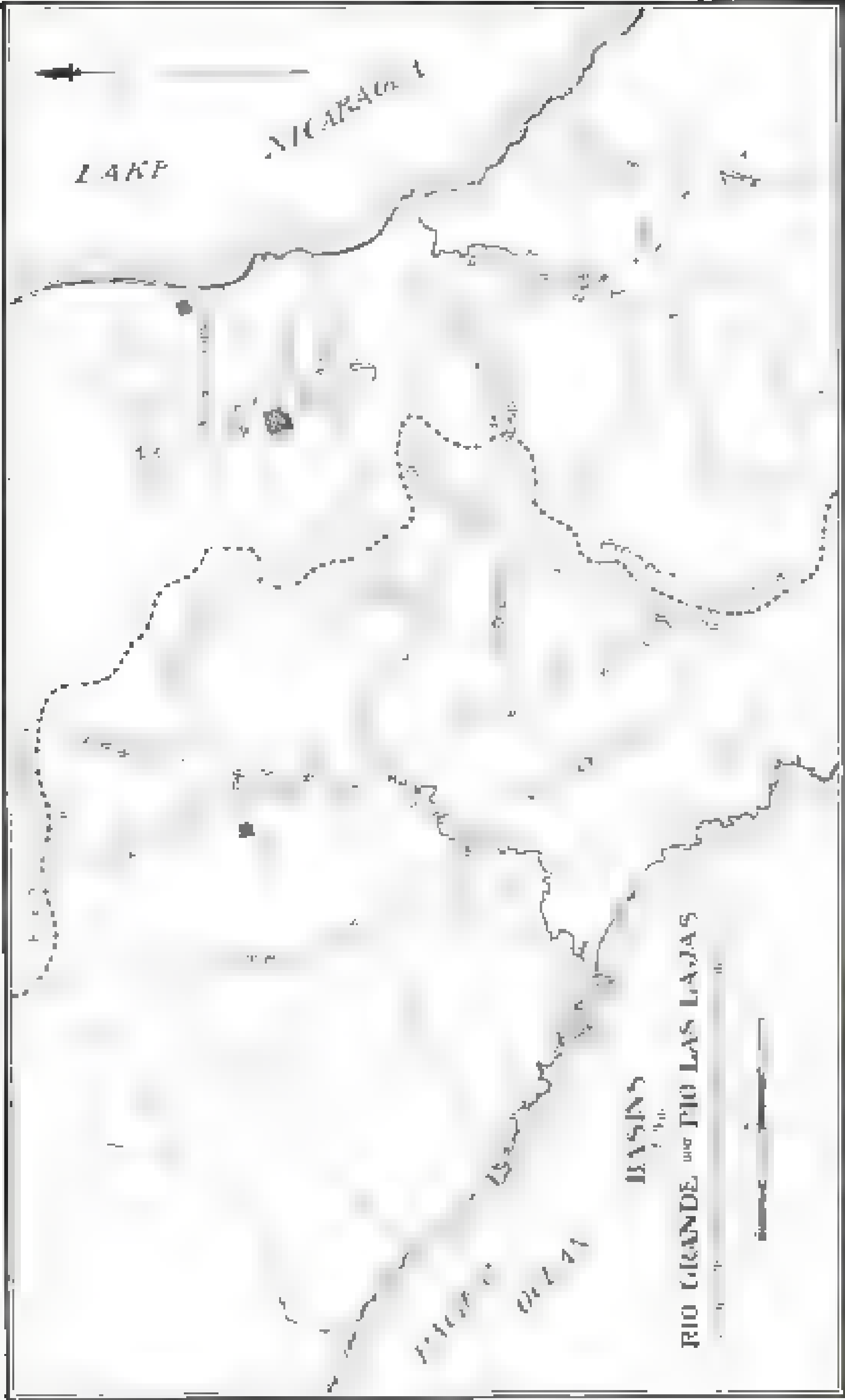
The map (plate 5), in which the present and former coast lines are represented, shows that a large land area has recently been added to this portion of the edifica. The topography of this region differs totally from that of the Nicaraguan depression more described. The latter is an old, and, now its surface forms are those developed by the processes of slow and degradation. The former, on the other hand, is composed of materials recently ejected from volcanoes, and it retains to a large extent its original constructional forms.

Extending through the center of the area in question is a line of volcanoes, all of which are geologically very recent, while some are still active. From these numerous vents, which were at first and continue vast accumulations of material has been erupted a large and broad, great volcanic plateau, from which rise more or less isolated volcanic cones. The southern base of these volcanoes are the twin peaks of Maderas and Chinetepe, which occupy an elevated Lake Nicaragua. Toward the northward are Zapatero, also an old island, Manacho, Managua, Chinetepe, and Comalito, the clustered peaks forming the Maricao range, and finally Cosiguina on the coast of Fonseca. Most of these volcanoes have erupted but once or have been long dormant, the latter varying from coarse blocks of solid lava to the finest dust. It is the fragmental material which gives to these volcanoes that beautifully even, nearly smooth forms. Those which have been recently active, as Chinetepe and Comalito, are now in perfect repose. The effects of erosion, however, are seen everywhere before the volcanic activity ceases, and the symmetry of the cones is quickly destroyed. The details of outline in the new cones vary from year to year. When the loose material has been removed or solidified by erosion the symmetry usually is the

irregularly rounded form seen in Matamor and Zapatero. In some cases the original summit is destroyed, not by the slower process of erosion, but by an explosive eruption. The result is an irregular jagged truncation of the cone, usually with a depression in the center occupied by a lake. This form is seen in Matamor and Cosgachin. Cosgachin is a truncated cone the former was once a conical peak, as this is well known, the summit of Cosgachin was blown off by an explosive eruption in 1843, the latest of its recorded eruptions, and is surpassed by that of Kilauea in 1881.

These volcanic cones rise from a level plain which stretches from the head of Lake Nicaragua northward to the Gulf of Mexico. It is now known a mass of fragmentary volcanic materials, which have now their present position probably in the form of a flood flow. The materials are well sorted though successive layers are separated by distinct planes. In a quarry near Matamor and in trucks have been found in this material, showing that it is very recent and also affording some information of the physical conditions under which it was deposited. To the south west of this plain and separated from it by a rather steep escarpment is a plateau which slopes somewhat gradually from an altitude of about 1,200 feet along its lower margin southwestward to the Pacific coast. This plateau is composed of exactly the same materials as the lower plain to the east, and it appears from a distance the two surfaces were once continuous, but have recently been separated by a fault.

From all the evidence thus far obtained, it appears probable that during early Tertiary time the waters of the Atlantic and Pacific had free unobstructed passage across the portion of the isthmus. The physical evidence that the rocks were covered also over a considerable portion of the isthmus and great masses of volcanic rocks were piled up upon them. In middle Tertiary time the region was elevated above sea level and there is no evidence that it has at any time since been depressed so as to give free communication between the two oceans. The elevation of the region was followed by a long period of erosion, during which the surface was reduced to a broad yet undulating plain mainly level with the center of the isthmus and from which only the streams flowed in separate sections eastward to the Gulf coast and westward to the Bay of Amaléc to the Pacific coast. After the surface of the country had been considerably reduced across this narrowest portion of the isthmus the region



PHYSIOLOGY OF ANIMALS & CASES LEFT

suffered another elevation. The streams were thereby elevated and began to breach the surface of the base level valleys which they had previously formed. Shortly after this elevation there was a renewal of the volcanic activity, which had been quiescent for a long time. This second distinct period of activity has continued down to the present time. It was manifested along two nearly parallel lines of vents. One of these lines gave rise to the Costa Rica volcanic range, and the other to the Toluca range. The vents forming the latter were situated along a line nearly parallel with the line of the coast, extending to the southwest, near the southern end of the bay which then occupied the Pacific coast. Vast quantities of lava and ashes were thrown out from these vents and their accumulation was such that the spreading lava fields formed a dam, cutting off the bay from the ocean. Since the precipitation was greater than the evaporation, the waters collected behind this barrier, and as the surface was gradually raised, accumulated upon the basins of the streams which had been tributary to the bay. The water doubtless continued to escape westward for a long time after the volcanic activity began, but great eruptions raised the lava so much in height that the streams could not pass it to the westward. They then escaped eastward to the Atlantic. The continental divide, which had previously occupied its present position near the Pacific coast west of the lake. When the waters of the lake first overflowed the divide to the east, where they were doubtless considerably higher than at present. The lateral forcing of the divide, however, was resisted by a deeply weathered rock, and the effect was quickly countered to the sand rock, where it has been held practically unchanged to the present time.

The latest episode in its geologic history has been the depression of this portion of the plateau to the extent probably of one thousand or two hundred feet. By this depression the lower portions of the river valleys were covered, forming great plateaus. The stream now going to the Pacific have it most, and is entirely filled with sediment. Thus the Colorado valley, which is removed by the western portion of the range to the south, and is separated from the main body of the plateau by a deep narrow gap, is now in width between the north and south margins of the older valley. This point extends out nearly even with the headlands, with a depression by a long curving gap.

A few of these Pacific streams have not yet completely filled the old valleys with sediment, and the undrained portion of one now forms the harbor of San Juan del Sur. The San Juan river flowing eastward to the Caribbean, has not only filled the estuary which once occupied its valley, but has pushed the coast line eastward by a broad delta point.

The San Juan river and its valley bears such an intimate relation to any canal scheme that a serious one must take account of its peculiar topographical features. It is rendered from any point of view, either with reference to the history of its development, the present character of its course and banks, or the possibility of using it for a canal route. The San Juan valley is naturally divided into three sections. Starting from the point where the river leaves Lake Nicaragua, the first extends to the head of the Toropays, the second from the head of the Toropays to the mouth of the San Carlos river, and the third from the mouth of the San Carlos to the sea.

In the upper part on the river has a moderate current and a considerable depth. Its banks are low and swampy, except where it swings against the foot of one of the numerous hills rising above the alluvial plain through which it meanders. It is evident that the lake formerly extended down to and beyond this point, and that a large amount of territory has been reclaimed from its waters. It is well recognized that lakes are accidental features, and the ordinary ways in which they are obliterated are (1) the filling from their upper ends and by the cutting down of their outlets. In this case, however, the first of these processes has been exactly reversed. The area of the lake is being contracted chiefly by raising at its lower end. The raising is being accomplished (1) by the water which comes from the lake, since this is, practically speaking, but by the tributaries which enter the lower portion of any of which have been converted into streams of the San Juan. The present river of an old lake bed does not occupy the position of the river which formerly occupied it as soon before it was absorbed by the waters of the lake. The position of the present river is the relative positions of the old lake bed and by the tributaries on either side, and it has opened toward the northern edge of the delta basin by the upper tributaries from the south. The canal from Poncha to Lake Nicaragua may best be considered as a *removal of river channel*. That is, a broad arm of the lake has been gradually constructed by the deposition of sediment at its margin, so that that remaining is the water-

row over channel kept open by the current of water flowing
from the lake

The second section of the waterway extends from the head of the Toropaya to the mouth of the main channel. It consists of a narrow strip of water 1/2 mile in width, the riverbed being narrow and low in water at low tide. The Toropaya is much better than the

present evidence is formed by a series of rock exposures in the valley, bank, and terrace south and east of the peaks and where the main canyon here extended down to the bottom of the present rather large, shallow, secondary, and less

near its head. A borer, and carried by the wind, a small amount of a very small and here there was deposited on reaching the water. A delta was thus formed, extending as a shoal across the river at the lake at this point. As the river continued to dig a bed across the river, the latter became narrower and the surface of the delta or drift, and the crest of the barrier which separated the crest of Lake Sturgeon moved westward from its original position at the former divide to the present position of the divide.

From the bend of the gorge roads to Morinda, a river channel composed of numerous small reaches separated by rapids. The total fall in this section is about 40 feet, or an average of two feet to a mile. Of course, however, a bit more than a foot is a drop caused by the numerous rapids. These appear to be due to the irregular topography of the underlying rocks. The

The large, flat sandstones are collected against softer rocks, which are worn away by the retreating current more rapidly than the harder rocks by the small current of the rapids. Between the channel and the mouth of the San Carlos the river is deep and narrow and the current is generally moderate. In some places at low stages of the river it is almost imperceptible, but when the San Carlos is in flood the current may even set to, and for a time the water has a race varying between 15 and 40 miles a day.

The bottom of over a mile long lake the points had was covered. It is evident that the present river is now flowing in a channel with a way out where the lake would gather than now and we are has not yet been filled by sediment. This part can be called the Long Mountain or near water.

The third section of the river extends from the mouth of San Carlos to the Gulf of Mexico. With the entrance of the San Carlos the character of the San Juan is entirely changed; the gulf section is a comparatively clear stream, and except at the

rapids has only a moderate current. Below the entrance of the San Carlos it is weak & muddy, it is shallow with a shifting sandy bed & has a but only strong current. Its slope is nearly a foot to the mile in this section. The Sacramento, it is nearer to the San Carlos, although somewhat smaller. Both of these streams have their sources on the slopes of the Cordillera, & flow as to the south. The recent volcanic eruptions of this region have furnished an abundant supply of arcose material, and in these streams and bay are heavily loaded with this material. Below the entrance of the San Carlos the floodgate of the

San Juan, as it is called, is not to the San Juan has

by that the floodgate is of the same or to the same

the latter are ponded in their upper courses and many rapids are thus formed. From the mouth of the San Carlos eastward the San Juan occupies the fort portion again of its valley. This is due to the fact that it is now a part of the river, & is loaded by the southern channels and also by the downward drift of the lateral current in the Caribbean sea. As the river extended its course eastward by the help of the estuary, and later by the formation of the delta, it was continually crowded to the northward by the action of the sand drift along the coast. The tendency became more pronounced the farther east the delta was built, and the sharp corner toward the north of the lower San Juan is its final consequence.

As the river channel was carried farther toward the northern portion of the valley would be filled first and to a higher level than the southern portion. The river would thus at times find itself in a position of unstable equilibrium, and would seek a new channel, on the lower part of the delta, to the southward. Thus it is probable that the river might have occupied the present position of the San Juanillo. When this position became unstable it gradually deserted its northern channel for the present position of the lower San Juan. Subsequently the latter became unstable, and a more favorable course to the sea was found still farther east. The recent channel of the Colorado was developed at the expense of the lower San Juan. This process is still going on, and the relative amounts of water carried by the two channels are very materially changed within a generation. Unless materially modified, the lower San Juan will continue to dwindle and probably the water will find its way to the sea by the Colorado or by some more favorably located channel still farther south.



Nicaragua and the Steam Routes

by A. P. Davis,

Hydrographer, U. S. Geological Survey

The state of Nicaragua is the largest of the Central American republics. It lies entirely within the tropic zone, and extends a little more than 1,000 square miles, or about one-fourth more than the state of Ohio, and is on the same meridian of longitude. It is bounded on the east by the Caribbean sea, on the west by the Pacific ocean, and lies between the republics of Honduras and Costa Rica to the north and south. The northern part is largely occupied by rugged mountains, except in the main axis of the Cordillera. A little farther south has been divided into two main sections, one following a westerly course, nearly parallel to the Caribbean coast, almost to the southern boundary of Nicaragua, where it is cut through by the San Juan river. The west end of the country follows the Pacific ocean, and is peculiar in its low position and the narrow strip of land it occupies.

The east coast for a distance of 20 to 30 miles inland is mostly of a very dry nature. High rolling country approaches the coast at Blue Key Point and near Greytown, but within these exceptions the coastal region is low, flat and during the rainy season is covered with water.

There is information regarding rainfall in Nicaragua, but extremely meager. There is a record of 10 years at Rivas, which began in January, 1880, and is still continued. This record has been voluntarily kept by Dr Earl F. Smith, an American resident of Rivas. A rainfall record was kept at Managua from July 1880, to December, 1906, by Mr A. L. S. machine. The observations were then transferred to Granada, and have been continued ever since, although results are at present only to the end of 1897. Observations of rainfall were also made in Granada in 1876 by Samuel Ferguson, and in 1877 by Dr F. H., also in 1883 and 1884 by the National Institute at Granada. At Bluefields observations were made by Hon. W. H. Jackson and others from September 1883 throughout 1884 and 1885 and a portion of 1886. The Nicaragua Canal Company kept a record of rainfall at

MILITARY AND THE INDIAN ROLES



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in a few American cities, even with the same luxury of topography, hills, gulches, fens, or any other city of Newburgh there is usually a taint of grass. By far the best buildings are the hotel and restaurant with a few small walks and a few steps or four feet wide, and change their grade with nearly every house they pass, so it is necessary to climb up or down one or two steps every fifty feet or so. The streets are dirt roads actually unpaved, and most of the towns are built on sandy or rocky ground so that good streets are scarce indeed.

The present project according to Newburgh from the American standpoint is the one suggested by the remarks of the topographers and the general conditions of a practicable route for a large ship canal.

These conditions consist of a large deep lake 100 feet above sea level, separated from the Pacific Ocean by a narrow strip of land, extending to the lowest depression in the continental divide between the Atlantic and the Pacific. The lake is a large navigable stream carrying two enormous locks from the lake to the continent sea. The route is especially fortunate

because at its exit at a level a few feet below and reservoir in Lake Newburgh, and by an ample drainage basin. The reservoir is built by first storing water for operating the locks of the canal but also for regulating the control of great floods that could only be prevented at practical points with a great cost. No other route enjoys advantages of this kind.

The San Juan river is the source of Lake Newburgh and its tributary drainage basin. Its total length from the lake to the sea is 120 miles, and it is usually large enough for light draft river steamers. It comes to a halt at Fort San Carlos at or about the varying from about 10 feet to a foot 100. Its course for a distance of 20 miles is through a low swampy country, re-

ceived and receives several tributaries of small size which in the dry season, are practically still water. The principal of these are the McIntosh, McQuinn, Pecos, and the Negro. The first tributary of importance to the San Juan river is the Rio Sabalosa, which comes from the north and empties 20 miles east of Fort San Carlos. About 10 miles below the mouth of the Sabalosa are the first rapids, called Toron rapids. These rapids are caused by boulders and gravel, probably brought into the river by Rio Sabalosa in former times, but the



the river is very wide and deep, and the water is very clear. The river is very wide and deep, and the water is very clear.

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U.S. DEPARTMENT OF AGRICULTURE

where f_1, \dots, f_n are the A -module
 f_1, \dots, f_n are the A -module

South American waters of the Indo-Australian Archipelago.

and has several patches of moderate grade. Various paper



The following table shows the results of the regression analysis for the dependent variable Y (in millions of dollars) against the independent variable X (in millions of dollars). The regression equation is $Y = 0.8X + 1.2$. The coefficient of determination is $R^2 = 0.95$.

locks close together near the Pacific coast, and the uncertainty of a sufficient water supply for the summit level.

The Transisthmian route is a direct line of the New Panama route, the project being to leave the Atlantic river about 20 miles from its mouth and then to cut a sea-level canal through a tunnel under the continental divide into the Pacific, the flow of the Atlantic river being diverted into the Pacific ocean. The direct line of communication from the Atlantic to the Pacific would thus be secured. The cost of the work has been variously estimated from \$120,000,000 to \$150,000,000. The chief difficulties of this route are the considerable excavation required and the control of the flood waters of the Atlantic river.

San Juan Route.—This route lies between the Gulf of San Blas in the Caribbean sea and the mouth of the Isthmus river on the Pacific. It is the narrowest part of the entire isthmus, being only 30 miles from ocean to ocean. It is proposed that the level of the water in this canal be that of ordinary high tide in the Pacific ocean. The sides of the Caribbean sea being considerably above sea-level, need be made to accommodate a level on the Pacific coast the slope from side to side 20 feet, and a lock would have to be provided for maintaining the canal at a constant level. At high tide the lock can be left open, while at low tide there would be a considerable rise of the water by means of the lock. This route requires the construction of a canal seven miles long, with a level exposed on the surface wide at the surface of the water and 10 feet high from the canal bottom. Much has been said in regard to the practicability and cost of the San Juan route, but it has yet been attempted and it is believed that the project is impractical, the constant evaporation of water from its roofs and sides, its disorganized canal, the would require by the use of water and the amount of low water, which would be unable to come out successfully the minimum and other engineering health which would be on the side of the canal to be required, and the accompanying uncertainty of cost and project complexity. The chief project of the San Juan route, the project to build this route has obtained a rapid and great public favor, and any other project of the Panama and Nicaragua routes.

Colon Route.—This route lies between Colon or Aspinwall on the Atlantic and Colon and Panama on the Gulf of Panama. The excavation of the Gulf bottom at one end and some of the roads at the other end of the route, and in the San Juan route was

western part of the route. The work was very slow, however, because of the dry weather. In fact, for the first 300 miles, the laborers had to dig a good deal of the road by hand, and it took an extraordinary time. The same line of work was continued for the remainder of the journey, but the suspension of the work, as a consequence of the

While an increase in the number of people taking the survey may strengthen the study, the survey is not a random sample of the population of 100,000, so the results may not be generalizable.

The last paragraph is a bit more complete in nature of a conclusion. It says that the project is not a total loss but is a partial loss. The second paragraph was a major loss, but the third paragraph was a partial loss. The fourth paragraph was a partial loss. The fifth paragraph was a partial loss. The sixth paragraph was a partial loss. The seventh paragraph was a partial loss. The eighth paragraph was a partial loss. The ninth paragraph was a partial loss. The tenth paragraph was a partial loss. The eleventh paragraph was a partial loss. The twelfth paragraph was a partial loss. The thirteenth paragraph was a partial loss. The fourteenth paragraph was a partial loss. The fifteenth paragraph was a partial loss. The sixteenth paragraph was a partial loss. The seventeenth paragraph was a partial loss. The eighteenth paragraph was a partial loss. The nineteenth paragraph was a partial loss. The twentieth paragraph was a partial loss. The twenty-first paragraph was a partial loss. The twenty-second paragraph was a partial loss. The twenty-third paragraph was a partial loss. The twenty-fourth paragraph was a partial loss. The twenty-fifth paragraph was a partial loss. The twenty-sixth paragraph was a partial loss. The twenty-seventh paragraph was a partial loss. The twenty-eighth paragraph was a partial loss. The twenty-ninth paragraph was a partial loss. The thirtieth paragraph was a partial loss. The thirty-first paragraph was a partial loss. The thirty-second paragraph was a partial loss. The thirty-third paragraph was a partial loss. The thirty-fourth paragraph was a partial loss. The thirty-fifth paragraph was a partial loss. The thirty-sixth paragraph was a partial loss. The thirty-seventh paragraph was a partial loss. The thirty-eighth paragraph was a partial loss. The thirty-ninth paragraph was a partial loss. The fortieth paragraph was a partial loss. The forty-first paragraph was a partial loss. The forty-second paragraph was a partial loss. The forty-third paragraph was a partial loss. The forty-fourth paragraph was a partial loss. The forty-fifth paragraph was a partial loss. The forty-sixth paragraph was a partial loss. The forty-seventh paragraph was a partial loss. The forty-eighth paragraph was a partial loss. The forty-ninth paragraph was a partial loss. The fiftieth paragraph was a partial loss. The fifty-first paragraph was a partial loss. The fifty-second paragraph was a partial loss. The fifty-third paragraph was a partial loss. The fifty-fourth paragraph was a partial loss. The fifty-fifth paragraph was a partial loss. The fifty-sixth paragraph was a partial loss. The fifty-seventh paragraph was a partial loss. The fifty-eighth paragraph was a partial loss. The fifty-ninth paragraph was a partial loss. The sixtieth paragraph was a partial loss. The sixty-first paragraph was a partial loss. The sixty-second paragraph was a partial loss. The sixty-third paragraph was a partial loss. The sixty-fourth paragraph was a partial loss. The sixty-fifth paragraph was a partial loss. The sixty-sixth paragraph was a partial loss. The sixty-seventh paragraph was a partial loss. The sixty-eighth paragraph was a partial loss. The sixty-ninth paragraph was a partial loss. The seventieth paragraph was a partial loss. The seventy-first paragraph was a partial loss. The seventy-second paragraph was a partial loss. The seventy-third paragraph was a partial loss. The seventy-fourth paragraph was a partial loss. The seventy-fifth paragraph was a partial loss. The seventy-sixth paragraph was a partial loss. The seventy-seventh paragraph was a partial loss. The seventy-eighth paragraph was a partial loss. The seventy-ninth paragraph was a partial loss. The eightieth paragraph was a partial loss. The eighty-first paragraph was a partial loss. The eighty-second paragraph was a partial loss. The eighty-third paragraph was a partial loss. The eighty-fourth paragraph was a partial loss. The eighty-fifth paragraph was a partial loss. The eighty-sixth paragraph was a partial loss. The eighty-seventh paragraph was a partial loss. The eighty-eighth paragraph was a partial loss. The eighty-ninth paragraph was a partial loss. The ninetieth paragraph was a partial loss. The ninety-first paragraph was a partial loss. The ninety-second paragraph was a partial loss. The ninety-third paragraph was a partial loss. The ninety-fourth paragraph was a partial loss. The ninety-fifth paragraph was a partial loss. The ninety-sixth paragraph was a partial loss. The ninety-seventh paragraph was a partial loss. The ninety-eighth paragraph was a partial loss. The ninety-ninth paragraph was a partial loss. The hundredth paragraph was a partial loss.

[illegible]

made a personal survey of the entire strip of land between the Arctic and Lake Michigan and made surveys of several routes to connect them. It did not seem to him likely to be possible to travel inland on account of the high elevation to be overcome. The first two routes of James A. Smith, by way of Lake Michigan, were considered as a route of its great commercial worth. This route involved a route to the Chesapeake with the following important points of landing on the shores of Lake Michigan: St. Ignace, Mich., Sault Ste. Marie, Mich., and then presented the great question of the construction of a canal and a railway etc. The remoteness of the route was a serious disadvantage, and the whole thing was

with a 14 ft. depth is required for the construction of a canal with a bottom width of 17 feet. He proposed to have a 10 ft. deep bottom with a 14 ft. side slope and a water level 10 ft. above the bottom. A deviation of 14 ft. was considered, with a maximum lift of 24 ft. If, in fact, the water was to be raised 10 ft. at a time, it would be



which is more valuable than almost any other in the North.

In 1880 Mr. Mercer was selected by the

committee of the way of Lake La as the first person to be

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AUGUST 1998

The undersigned is a duly qualified and duly sworn
to the said matter. All the same being duly
advised and that the said project is being done, etc.

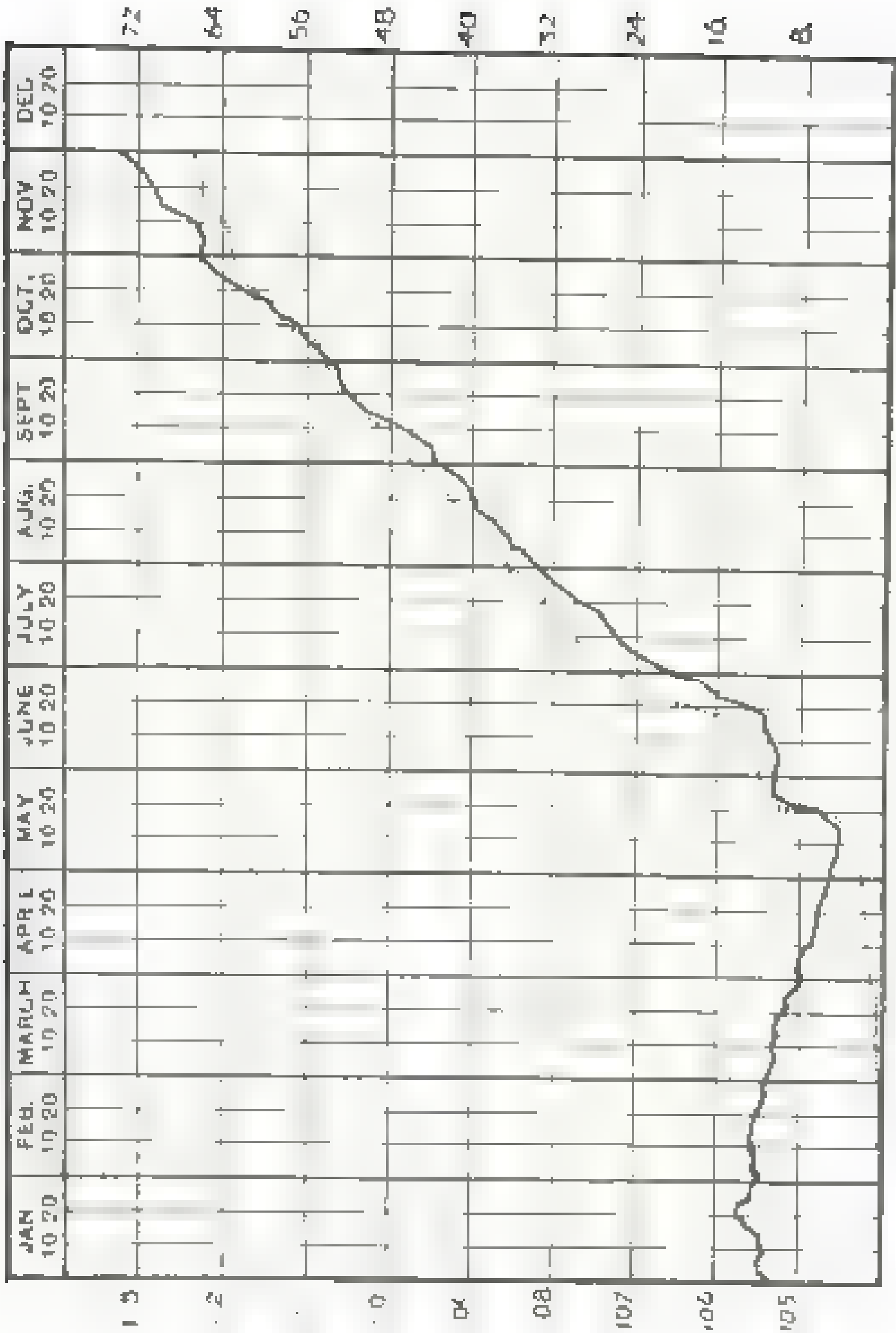
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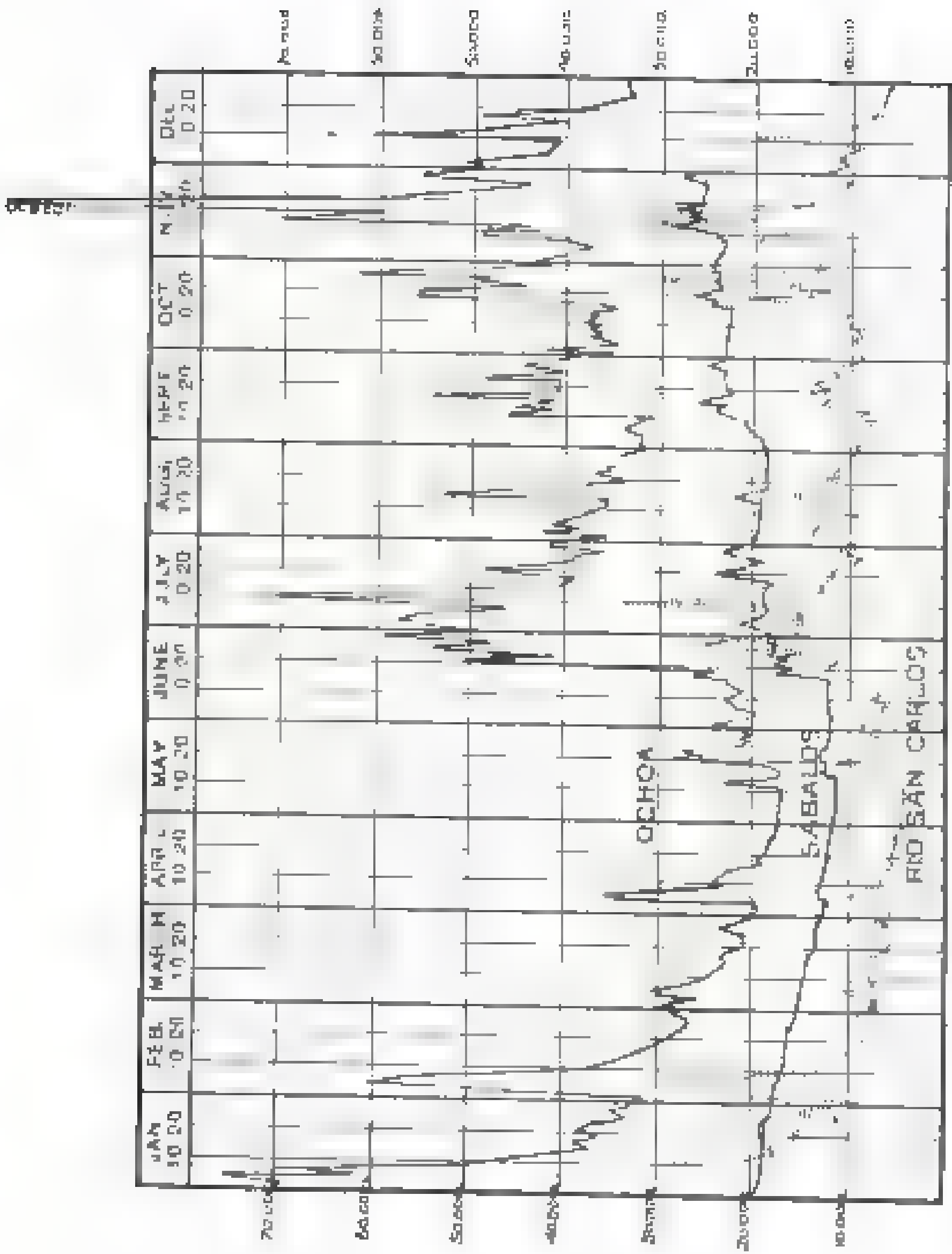
Lower Adair, W. W. and P. C. Thomas and Lewis M. Johnson
for the first time ever and exact location of the ...

The results of these tests are shown in Table 1. Although the results are not statistically significant, the data suggest that the use of the word "and" in the sentence "The car is red and the car is blue" is more likely to be interpreted as a conjunction than as a disjunction. This is consistent with the idea that the word "and" is used to connect two related ideas, while the word "or" is used to connect two alternative ideas.

The structure of large rocks, mostly detached, that were
a little higher up toward the top of the style of design, re-
vealed the use of rocks of very irregular and of hard and per-
manence structure. The style was found to be a simple
one, though the style of the design was a simple one.
However, it seemed to me that the existence of the style was
a very small one, and that the style was a simple one.
No satisfactory information was obtained from the
Indians as to the San Francisco or American. The large
amount of the design was found to be a simple one, and
the style was known to be a simple one. The style was
found to be a simple one, and the style was known to be a
simple one.

The greatest difficulty, however, was with reference to the hydrography. This, it was proposed to deal with the





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that and that the normal lake summit level. There is a minimum discharge of 100 feet and it is necessary to secure and hold a depth of 10 feet at the beginning of every dry season. There are very strong currents, however, and we have seen a current about 100 ft. in width, the velocity of which exceeds the minimum by two feet, so that a boat should be at full speed the whole time, or only very rarely at the rate of $\frac{1}{4}$ foot per second, the speed of such dry seasons is a matter of death or life.

Only two streams carried any considerable quantity of water in the last two years. These were the Rio de San Carlos and the Rio de San Juan. The Rio de San Carlos, which discharges 100 ft. at the extreme low water. It was in 1902, however, that the year round flow was 100 ft. in the Rio de San Juan, during the dry season, at least, estimates from 10 to 25 feet deep. A dense vegetation grows in great quantities in these streams, making the channels, unless a passage for navigation is kept open by canoes. This vegetation is not rooted to the soil, but floats freely and shows no disposition to flow out toward the lake. The water is dark-colored, brown and stagnant. When the rainy season sets in, however, these waters, deep channels are filled with a rapid current so swift that it is very difficult to paddle a canoe against it. The floating vegetation is carried out in great quantities, forming floating islands several hundred feet across. As the current of the stream flows gradually far out into the lake, the floating vegetation forms a large mass, through which one may at some times navigate quite an annoyance to navigation. Some of these islands find their way to Rio San Carlos, and pass down the San Juan river. The flow of the lake is estimated as from 20,000 to 30,000 cubic feet per second and to prevent any serious emergency of a going property it is necessary to provide a roadway of large capacity, and to control the discharge so as to waste the surplus and yet to store the large amount of water necessary to provide for the evaporation from the river surface.

In estimating the problem solved by the survey, the extreme flood discharge of Rio San Juan at Uchire was estimated by the company at 100,000 cubic feet per second. A discharge of a million cubic feet per second has been already observed, and a study of the flood, and in connection with the observations at the same point shows that the maximum discharge cannot be less than 200,000 cubic feet per second, or more than three times the estimated maximum. The San Carlos and Terapich rivers

THE WELLMAN POLAR EXPEDITION

We did not expect that great demands have been made for the services of Mr Wellman and his party, especially in view of the fact that the majority of them have not reached, or not further north than this have yet attained. They are the best work, ever and with few plans in their minds, but none of these things expected has to be done. There is no reward, but even that is a reward. The story of the expedition and a strange of our expedition has been told by Mr Wellman, *The Polar Voyages*, 1892—1893, and is moderately and absolutely free from the exaggeration that is so common in such narratives. It was my good fortune to assist

him in all preparations for his trip, and from his experience of travel in the Arctic, of conditions of the Arctic, and of the people now who he was prepared to meet, and so everything is very true. He and I together by the time of all who had gone before, and with a good number of excellent boats that gave some of the most interesting and easy. I think it is probable that the expedition of the Arctic, if he is true, that he will reach the North Pole.

I returned to London early from Toronto, intending to take advantage of a very breaking up of the ice, and in fact, it is the only one which was not reached. The expedition, except for the ice, is still with us, and he was compelled to put on his Norwegian or Canadian, that make a second attempt. This time he pushed through it, and I did not find it as difficult as I had feared. He had found the ice was very easy, and a few more men, and a few more days of summer sailing, and it was a good thing for the men and the ship. The rest of the party would find it very much more difficult, and being so, the heavier equipment for the winter months, the flying equipment, and the sledges, and the sledges, and the sledges.

One of the best features of Mr Wellman's plan is the way in which he has arranged to get the sledges. For it is the sledges that give him the most of waste in the power and material. He has arranged to avoid the usual dragging sledges of the Arctic by using a great many sledges, and having eight sledges. One of the best pieces of the sledges, with a sled every one, has been taken, after was the good use of the sledges, and the sledges have been taken. Of the five Norwegians in the party three have repeatedly en-

The second party in charge of Mr E. C. Schuchert, geologist, and Mr T. C. Gardiner, topographer, will proceed by the now well established route down the Yukon to Fort Yukon, or some point in that vicinity whence a convenient route northward can be found. The equipment will be the same as that used last summer, consisting of an ocean of outfit, but on the way, a pack animal carried beyond this saving point the route is left to the discretion of the relief of the party, but the general instructions are to penetrate the basin of the upper Kuyukuk as far as possible. The main purpose of this expedition is necessarily geographic, but a large amount of information will be gathered so far as practicable. It is expected that valuable information will be gathered to determine future plans for the exploration of the region between Bering sea and Arctic ocean. This party will continue its work until forced to retreat, or to a retreat of winter and will then descend on the swift current of the Kuyukuk river. Neither party will winter in Alaska. Although the many types of such expeditions have been recognized, careful consideration shows that none is comparable with present knowledge and available means.

METEOROLOGY IN THE PHILIPPINES

In view of the present position in the Philippines, through the recommendation of a private letter addressed by the director of the Manila General Observatory, the action taken by the United States government in suspending all telegraphic transmission warnings made by the Bureau of Meteorology for points outside of the Philippines.

It is proposed to present for the information of all persons of interest a copy of a statement of the facts and circumstances which led to the action taken by the United States authorities.

The communication dated November 5, 1918, from W. Indares, Director of the Hongkong Observatory, forwarded to the United States Weather Bureau, and the Manila Observatory was received in Washington during September 1918 in warnings of the typhoon season. It is proposed that this document was again submitted to the regular meeting of the Board for the guidance of the Board in its deliberations, which probably occurred entirely in the country. It is proposed that the American government of the Philippines should be informed of the facts and circumstances of the typhoon season, which is a matter of great importance to the Philippines, and that the American government of the Philippines should be informed of the facts and circumstances of the typhoon season, which is a matter of great importance to the Philippines.

and on the recommendation made by Dr Doherty, approved by the Chief of the United States Weather Bureau, the Secretary of Agriculture requested the Secretary of War to provide for a revolving telegraphic typoman warnings for the Manila Observatory to provide outside of the Philippine Islands. The position taken by the United States authorities was that the Manila Observatory was improperly interfering with the British Observatory's service with regard to the territory covered by the Observatory at Hong Kong, that all warnings of hurricanes should not be sent except upon the request of the British Government. It is to be noted that as Director of the British meteorological Observatory, Doherty had served over these colonial matters for the British Government in China. Dr Doherty would not be justified in sending weather forecasts to Manila, and that sanction on his part was, with propriety, be refused by the officials of the Manila Observatory. In this position they were strengthened by the great obstacles that have for many years existed between the prominent meteorological services of the world. The United States and Canadian meteorological services never presume to issue forecasts or storm warnings for any part of the territory under the sovereignty of the other nation, although they have in their possession daily meteorological observations from observatories both in the United States and Canada.

The British Government has a chief observatory at Hong Kong and possesses a number of meteorological observatories extending from the coast eastward to 88° E to 144° E, and southward and inland on receives reports from Indo-China and of Luzon. In fact, the director at Hong Kong possesses a system of observations which is necessary to the issue of forecasts that are worthy the serious attention of mariners. The limit of the Manila Observatory of issuing all storm warnings for Hong Kong and the Chinese coast was not only contrary to a permanent usage, but was not justified by the possession of superior facilities for making forecasts. The relative accuracy or value of the two agencies is shown by the Hong Kong and Manila observations and the comparative mean difference of the direction of the two observations and the difference of the position and the bearing of the stations. Dr Doherty has by years of well-directed work and at last established a forecast service and has achieved a high standing as a meteorologist, and is unquestionably entitled to the consideration and courtesy which usage has accorded to directors of meteorological services.

THE MISSION OF THE "ALBATROSS"

The Peary Arctic Club, under whose patronage Civil Engineer Terry, U. S. N., is now engaged in an expedition to the North Pole, will dispatch the steamer *Thetis* about the middle of June on the second of a series of annual reinforcements proposed by Mr. Peary. The original plan of expedition. The *Thetis*, a 47-ton steam-hulled merchant steamer, built in Sweden in 1881, and thoroughly refitted, reengineered, and reinforced in 1891, was engaged by the Canadian government during 1897 in the exploration of the water route for communications between Hudson Bay and Liverpool. She is a fast, staunch, and roomy vessel, and the best which has yet been employed in the northern work.

The mission is to be commanded by Capt. Sumner W. Bartlett, of Boston, Newfoundland and Labrador, and assisted by a select crew of Newfoundlanders, familiar with the conditions of the region. Mr. Bartlett has a brother, Capt. John Bartlett, of the *Albatross*, and a nephew, Capt. Harry Bartlett, of the *Falcon*, who were engaged in Peary's expedition. The former has returned from the expedition of last summer, and the latter was lost with his ship and all on board when returning from Philadelphia to St. John in the fall of 1894. The *Thetis* will carry a scientific party headed by Prof. William L. Giller, of Princeton University, for biological and geographical work, and a hunting party of four, led by Mr. Joseph W. Foster, of Boston. The first object of the United States Geological Survey of Washington, with two companions, will be to visit the *Thetis*, to be landed, if practicable, on Enderby's land, where he expects to remain for one or two years. Prof. William L. Giller, with a complete equipment of outfitting equipment, is expected to work in the coal and oil fields of Enderby's land. Determining the course and direction of the ice flow is another object. The hunting party will be taken by the best and wisest hunters on the coast of Labrador and the Arctic.

The *Thetis* will have one year's supplies for the expedition party, which has not returned, and for her own party, so that in case of any unforeseen accident there will be no danger of lack of food. She will also carry mail and small packages from Norway for Sweden, and the *Thetis* will have not seen her) from some time ago, and from Upernivik, July 18, 1895. The history of the *Thetis* is not planned by Mr. Peary to be a voyage for a month but some more. The hope of meeting Terry or his representatives will be of a nature of some concern concerning the work of the *Thetis* of the *Thetis* and the *Thetis* will make the voyage of this expedition one of the most popular scientific interest.

It is reported that in a resolution of the Royal Geographical Society which went into effect a few days since, it got Hon. Arthur J. Balfour to be a member of the Treasury proposed that the government would render a subsidy to and in furtherance the work of an Antarctic expedition.

GEOGRAPHIC LITERATURE

A Thousand Days in the Arctic. By Frederick C. Jackson, Lieut. U. S. A. With Illustrations by F. L. Benson. Macmillan & Co., pp. 320 + 1340 (with many illustrations, including five original maps). New York and London: Harper & Brothers, 1894. \$5.

There is an unvarnished tale of a thousand consecutive days spent in the Arctic, presented almost as it was, as it were, by the man who was there, when on sleds or on foot, by journeys in Franz Josef Land. It is a simple, true account of the adventures of body and heart to life and work there—plain facts, pictures of a polar man. Such is the depository of an modestly reflected by one of the foremost explorers of the decade to the most exact record of his work. Frederick C. Jackson, a German of ethnographic, geologic and zoological views, is one of the best informed by the signs of the continent of Asia, although a native of one of the most fertile regions where humans are scarce and whose strange are scarce. On studying his expedition it seemed to him probable that Franz Josef Land discovered his names by Weyprecht and Payer in 1871 might also be seen at once to the pole, as he, after many unsuccessful attempts, had at last effected a connection with Mr. Alfred C. Harnow, a German, upon an expedition for geological work in the Arctic. His land of a native patron was not more troubled by the purely polar glow of a land explorer. It was his chief desire that Jackson should be more particularly to his knowledge of the geology and the natural history of Franz Josef Land and the surrounding and study north of the 71°. The time of a particular visit to the *Humboldt*, with the Jackson party on board, weighed anchor on July 2, 1894. A further expedition to Franz Josef Land was reached within three days, and a landing was effected, and before the transfer of goods was completed the vessel was caught in the ice, and remained so for a week of 18 days when it returned to England, leaving Jackson and Harnow with a small party of five in the most desolate spots ever known by explorers. Nearly a year of arduous study was followed by the most successful result of Arctic exploration, the discovery of the Vanner and J. J. Harnow, who returned to the Arctic with a party of 11. Discovered on the return of 1896, which the Arctic party remained for an entire year, to the north, and by the same vessel to the shore of 1896. By eight or ten years of labor under severe conditions, the Arctic party were able to find a large number of fossils, including plants, which were not known before, and in the Arctic were found the supposed conditions and is but an approximation. The Arctic region is a barren, but to say for all by, and it was made to be a somewhat more comfortable with the result of a large of the Arctic region and the discovery of the Arctic region, a point of Franz Josef Land. A further expedition

These results, which are descriptive forms only, are given in the following tables. The first table shows the results of the first survey, and the second table shows the results of the second survey. The third table shows the results of the third survey, and the fourth table shows the results of the fourth survey. The fifth table shows the results of the fifth survey, and the sixth table shows the results of the sixth survey. The seventh table shows the results of the seventh survey, and the eighth table shows the results of the eighth survey. The ninth table shows the results of the ninth survey, and the tenth table shows the results of the tenth survey. The eleventh table shows the results of the eleventh survey, and the twelfth table shows the results of the twelfth survey. The thirteenth table shows the results of the thirteenth survey, and the fourteenth table shows the results of the fourteenth survey. 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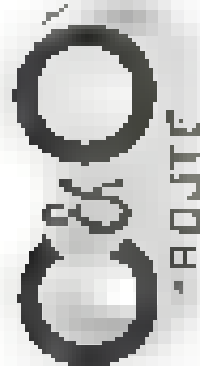
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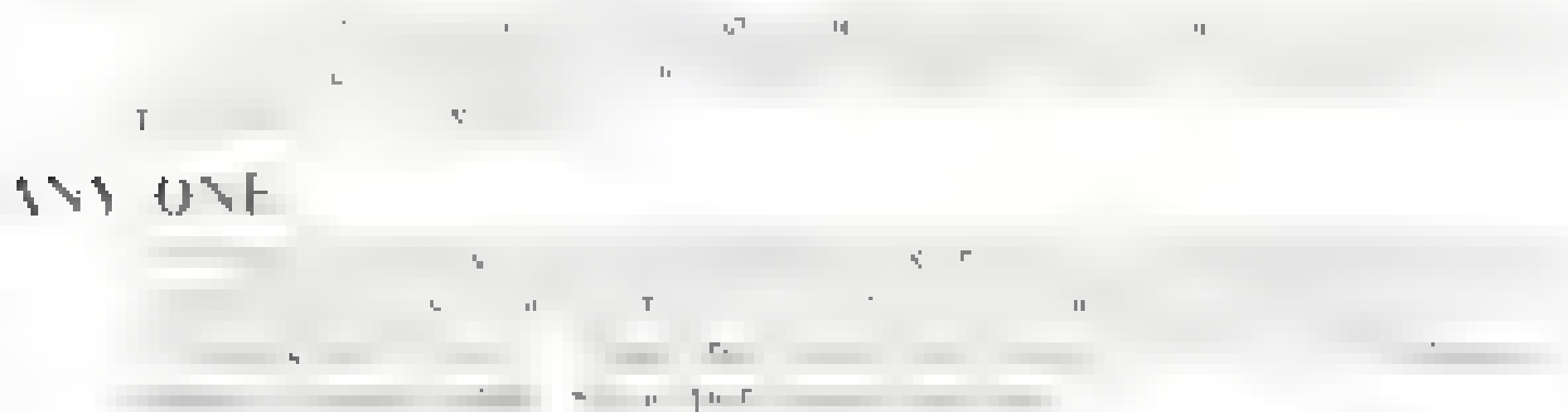
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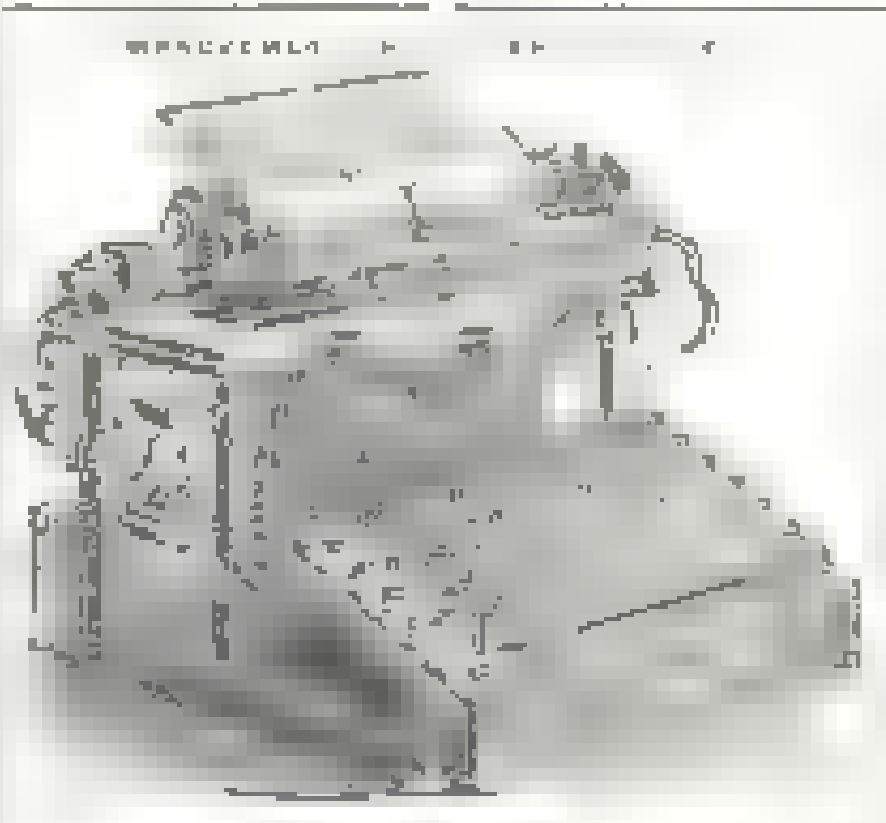
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